# Hydraulic System Design of Endless Rope Winch

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## Abstract

**The endless rope winch has many advantages, such as simple operation, easy installation, less investment, low cost, long transport distance, transportation continuity and so on. It is very popular in coal mine auxiliary transportation. However, the traditional electric winch requires high starting speed regulation, and the design of the electric control system is complex. The explosion-proof problem caused by the heating of the motor also brings certain safety risks to the coal mine production. Considering the special working conditions and the advantages of hydraulic technology in coal mine, hydraulic pump is used to drive hydraulic motor instead of explosion-proof motor to drive the winch drum directly. This makes the structure of the winch greatly simplified, but also can be infinite speed regulation, to achieve simple installation and maintenance, easy to use, save manpower, safe and efficient, reliable operation purposes.**

## Keywords

**Endless rope winch, hydraulic principle, lectotype design.**

## 1. Introduction

The endless rope continuous haulage winch is an ideal equipment to replace the traditional small winch relay and opposite haulage mode and realize the transportation of heavy and light hydraulic support and various mine equipment and materials[1-2]. The endless rope continuous tractor has special functions to realize the horizontal turning transportation of the roadway. Explosion-proof hydraulic winch is a kind of explosion-proof equipment, which changes the traditional way of using pure mechanical transmission, and adopts hydraulic motor-driven, high-power hydraulic pump, especially suitable for use in the dangerous environment of coal dust and gas explosion. Such explosion-proof equipment can fully adapt to such inflammable and explosive environment.

The hydraulic motor is driven by hydraulic pump instead of the original explosion-proof motor to achieve stepless speed regulation. The high pressure oil produced by the hydraulic pump is used to drive the hydraulic motor to rotate. The motor drives the original reducer and then drives the drum to work. It ensures that the starting operation is stable, and at the same time heavy load and low speed operation are realized, and the light load is operated at high speed. Hydraulic pump is used to drive hydraulic motor instead of the original explosion-proof motor to ensure stable start-up and realize stepless speed regulation. The traditional electric control system is replaced by hydraulic speed control system, which makes the electric control structure simple and improves the explosion-proof performance of the winch.

## 2. Design Analysis

The hydraulic winch is divided into two parts: the design of the mechanical transmission system and the design of the hydraulic transmission system. The hydraulic system is powered by an electric motor and transformed from a hydraulic pump to a system oil pressure[3]. The pressure oil is fed into the hydraulic motor through various control valve blocks, and the hydraulic motor converts the oil hydraulic pressure into mechanical energy[4-5], and into the mechanical transmission system of the hydraulic winch, *References*, see Fig.1.

Formula for traction force:

$$F=[m(0.02\cos\beta+\sin\beta)+\mu qL]g \tag{1}$$

In the formula: m-traction mass; β-maximum slope of beta-running line; μ-resistance coefficient of mu-wire rope; weight of q-unit length wire rope; L-transportation distance.

Winch input torque formula:

$$Tw=Tg+Tf+Ta \tag{2}$$

In the formula: *T*w- winch theoretical input torque; *T*g- load driving torque; *T*f- shaft friction torque; *T*a- moment of inertia.

Theoretical working pressure formula of hydraulic pump:

$$Pp\geq P_1+\sum\Delta p \tag{3}$$

In the formula: *P*1 -hydraulic cylinder or hydraulic motor maximum working pressure；ΣΔ*p*- pipeline loss from outlet of hydraulic pump to hydraulic cylinder or hydraulic motor inlet.

Calculation formula of hydraulic motor flow:

$$Q\leq\frac{Q\mathrm{vp}}{K} \tag{4}$$

In the formula: *K*-system leakage coefficient; $Q_{vp}$-hydraulic pump output flow.

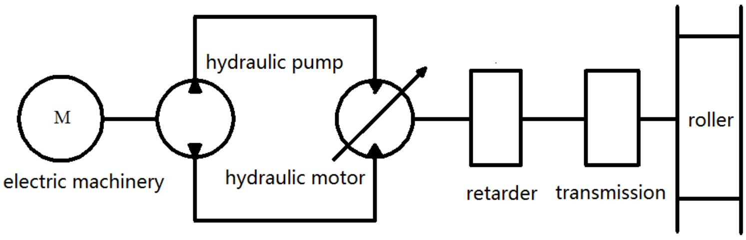


Fig.1 Transmission plan of hydraulic winch

## 3. Hydraulic System Design

### 3.1 Hydraulic Principle Design

The dual pump oil supply system is used to control the reversing speed of hydraulic motor by the main oil circuit. The oil circuit is controlled to provide pressure oil for hydraulic tension device and brake device, and the main oil circuit is controlled by the hydraulic control reversing valve, *References*, see Fig.2.

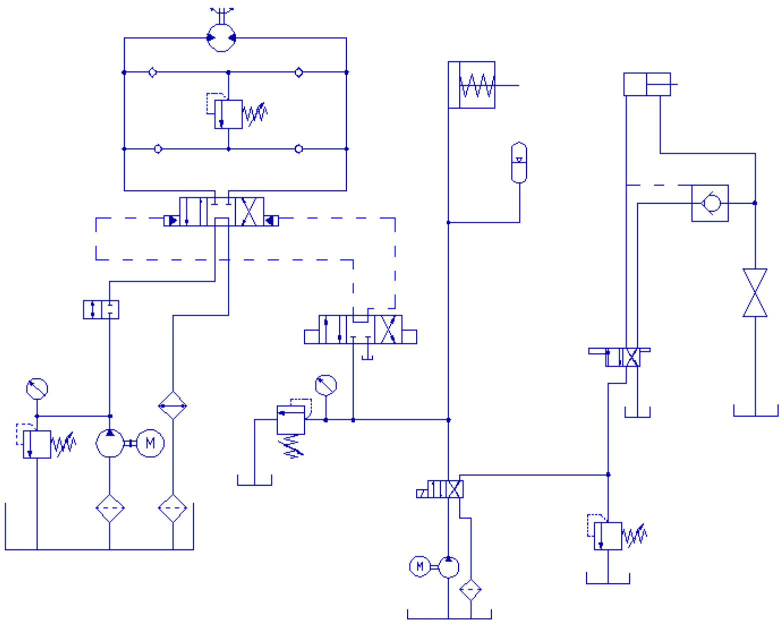

Fig.2 Hydraulic schematic diagram

Hydraulic system action actuator is mainly composed of three parts, namely, the left side of the hydraulic motor, the middle of the brake cylinder, the right side of the tension cylinder. Firstly, the auxiliary oil pump is filled with liquid for the tension cylinder. When the pressure reaches the preset pressure of the hydraulic control one-way valve, it starts to move and the cylinder is filled with liquid. The brake is loosened by pressing the auxiliary pump into the brake cylinder to keep the tension cylinder under pressure through the manual directional valve. Open the main oil pump, through the control of oil circuit reversal and speed control to control the action of hydraulic control valve reversal and speed control of hydraulic motor.

### 3.2 Lectotype Design

It is preliminarily determined that Shunwei HVP series vane pump HVP-2-F70A4 is used for the main oil line hydraulic pump, and medium and low pressure series NB3-D25F is used for the control oil line. Considering the simplification of the transmission system structure, the small displacement, low speed and high torque hydraulic motor is more conducive to improving the stability of the system operation, it is preliminarily determined that the QJM series ball plug low speed and high torque hydraulic motor is adopted, and the 1QJM1A1-0.63 radial ball plug rotary hydraulic motor is pre-selected.

## 4. Conclusion

This paper analyzes the application value and advantages of hydraulic winch, designs a transmission scheme of infinite rope hydraulic winch, gives the design formula of key parameters of main components, and provides design ideas and theoretical reference for hydraulic winch design. Based on the analysis of speed regulation mode, the hydraulic circuit is optimized, and a set of double pump oil supply hydraulic circuit with speed regulation, tension and braking function is designed.

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